former photograph taken in 1889, July 28, indicated also the same nebulosity. The exposure in the former case was of 3h. 29m. duration, a Willard lens of 6-inch aperture being used. The position of the star for 1860 was R.A. 18h. 9m. 23·2s., Decl. – 19° 42′·7.

Atmospheric Depressions and their Analogy with the Movements of Sun-Spots.—The solar photosphere, although so different in chemical composition from our own atmosphere, yet affords us many points of resemblance with regard to its general circulation. One special analogy, and that a comparison of the motions of storms here with those of spots on the solar surface, is treated of in the July number of *L'Astronomie* by M. Camille Flammarion. In this article he has brought together sufficient observations to trace out the paths of many of the most violent storms that have from time to time visited Europe generally. The first storms which he gives are those which occur in the Atlantic; their general direction of motion seems to be from south-west to north-east, pursuing generally the path of the Gulf Stream. Their centres, when traced on a map, seem to just graze the shores of the British Isles, France very rarely being reached by them. From observations made on land, and more especially from those at Paris, M. Flammarion remarks that certain curves with regard to these storms seem to offer many analogies to solar spots; this is so not only for the regular displacements, but even for those which at first sight seem to be totally void of all regularity. The diagrams which he gives, showing both the paths of the storms and those of sun-spots, afford most interesting comparisons and seem to confirm the view suggested by M. Faye that the constitution of spots resembles somewhat that of the cyclones with which we are familiar.

Yale College Observatory Report.—In this report, submitted by the Board of Managers to the President and Fellows of the Yale Observatory, Mr. Brown makes us acquainted with the present condition of the Observatory generally, while Dr. Elkin gives an account of the work done by the heliometer during the past year. The satellites of Jupiter formed the principal object of work from July 1891 to January 1892, 570 complete measures of their relative positions having been obtained on 114 nights. Dr. Chase, with the same instrument, has been measuring the cluster in Coma Berenices, securing from 18 to 20 measures for each of the 32 stars, besides determining the required data for the reduction-constants. In the work on the parallaxes of the first-magnitude stars in the northern hemisphere, the 100 sets of measures of each of the ten stars have not yet been fully completed, but the following table shows the results obtained up to the present, Dr. Elkin thinking that it will require two more years before the final results can be published:—

Star.	Parallax. ″	Prob. Error. ″	No. of comp. stars.	No. of Sets.
α Tauri	+ 0·101	+ 0·022	6	65
α Aurigæ	+ 0·095	0·021	5	51
α Orionis	+ 0·022	0·022	6	48
α Canis Minoris	+ 0·341	0·020	6	48
β Geminorum	+ 0·057	0·021	6	48
α Leonis	+ 0·089	0·026	10	43
α Bootis	+ 0·016	0·018	10	89
α Lyræ	+ 0·092	0·019	6	67
α Aquilæ	+ 0·214	0·023	10	46
α Cygni	+ 0·012	0·020	7	49

GEOGRAPHICAL NOTES.

The condition of affairs in Uganda, of which much has recently been made in home and foreign newspapers, is a question rather of politics than of geography; yet problems of a geographical kind are involved in it. So far the progress of civilization amongst the Waganda has served only to introduce new elements of dissension, and the attempts to carry out the policy of preventing the sale of spirits, firearms, and ammunition have only been partially successful. Scientific exploration in a country so unsettled must necessarily be suspended. If the British occupation is to be productive of benefit either to British trade on the one side or to native interests on the other, the firm and impartial rule of Captain Lugard and Captain Williams must be maintained and reinforced. The urgent request which these officers have made for additional white assistance demands all the more attention since the garrison under their control has been swelled by the survivors of Emin's force in Equatoria.

Although, as announced in Nature (p. 230), Captain David Gray's Antarctic expedition has fallen through, it is satisfactory to know that three Dundee whalers, which are shortly expected back from the Arctic "fishing," will be refitted immediately and despatched about the beginning of September to the Falkland Islands, and as far to the south as may be necessary in order to get a cargo. The proposed cruise is to be purely commercial, and it is not likely that any exploring work will be done. It is probable that berths will be available on board for two or more scientific men, who should have good opportunities of collecting natural history specimens. The experience of the whale-ships will be valuable in supplying hints for the equipment and route of the great Antarctic expedition which under some European flag cannot be long delayed.

Dr. Oscar Baumann, charged with the survey of a road to the Victoria Nyanza, reached the shores of that lake in April, after an unprecedentedly rapid journey from the coast. From the *Times* report of a letter written by Dr. Baumann from Kadoto, we learn that the route, after passing around Lake Manyara, struck across an unknown stretch of country in which a new lake of large dimensions was discovered. Even in Africa few lakes of such magnitude can now remain unknown, at least from native reports. Lake Eiassi lies on the plateau south-east of Victoria Nyanza, and from the report of the neighbouring Masai, it seems to be about ninety miles long, while the breadth of the northern portion, along which Dr. Baumann marched, varied from eighteen to thirty miles. This lake is presumably filled with fresh water, but no outlet is mentioned. It is interesting, however, to find native reports of a great river flowing in on the western side, which may be confidently identified with the Wemberi, a river shown on recent maps as flowing north-eastward from the border heights of Unyamwesi, and losing itself on the plateau. It is possible that the new lake may discharge into the Victoria Nyanza by the Simiu river, the head waters of which have not previously been explored.

The recently founded New Zealand Alpine Club has published the first number of its *Journal*, devoted to the exploration of the glaciers and peaks of the Southern Alps. The magnitude and difficulty of these snow mountains of the south has hitherto been very inadequately realized.

THE MUSEUM QUESTION.[1]

Gentlemen of the Museums Association,—In taking the chair which was so ably filled by my predecessor at Cambridge, I must first of all give you a hearty welcome on the part of the Committee of the Manchester Museum. There is to my mind a singular fitness in the selection of Manchester as a place of meeting after Cambridge. At Cambridge you had the opportunity of studying the various museums which have in the course of time naturally grown out of the development of that ancient seat of learning. In Manchester you will see the collections which have been gathered round Owens College, which represents the newest University development in this country. The genius of the place has left its mark in both. In Cambridge the collections are, as they should be in a region of academic calm, free from trade-winds, arranged mainly, if not entirely, with an eye to University students, and not for the general purposes of a miscellaneous public. In this busy centre of movement and commerce, you will find that the principle of arrangement is twofold. It first aims at meeting the needs of the University students, and of the Mechanics' Institutes, and schools, and other educational bodies, which are daily being drawn closer to Owens College, and next at the instruction and enjoyment of the general public. Our collections are for the most part older than the college and have been absorbed from without into our educational centre.

The problem which we have attempted to solve is this: How to arrange and organize collections which are in part as old as the second quarter of this century, so that they may become valuable in the new learning and at the same time put an outline of the history of nature within reach of the people. This problem, as we all know, is not an easy one. It has, however, to be faced in most of the museums of this country. Whether it has been solved or not in Manchester, it is not for me to say. Prof. Huxley, in addressing us some years ago on the question of technical education, said that he did not know exactly what shape it should take, but that Manchester was a good place in which to make an experiment for the good of the Commonweal. *Fiat experimentum in corpore Mancunensi.* The result of our experiment in museum organization is here and speaks for itself.

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[1] Address to the Museums Association, Manchester meeting 1892, by the President, Prof. Boyd Dawkins, F.R.S.

Before, however, I deal with this special attempt to meet the needs of Manchester I must touch on the general question of museums.

The Museum Idea and its Place in Culture.

A museum was to the Greeks a place haunted by the Muses, and in a secondary sense a building in which liberal studies were carried on such as that at Alexandria, which was a great University endowed by the State, divided into colleges, and frequented by men of science and letters. This museum included picture galleries and statuary, and it is not at all improbable that it contained also collections of Natural History. Aristotle, it must be noted, made vast collections, which he used in his history of animals, by the aid of his friend Alexander the Great, and it is hard to believe that the impulse which he gave to the study of natural history should not have been felt in Alexandria, where his memory was venerated. With the destruction of this museum in the days of Aurelian in the last quarter of the third century after Christ, the name as applied to a public institution gradually dropped out of use, and was only revived with the revival of learning in the West in the times of the Renascence. We owe the first idea of a great national museum of science and art to the "New Atlantis" of Lord Bacon, the first scientific museum in this country to Elias Ashmole, who founded the museum which bears his name in 1667 at Oxford. It consisted mainly of the natural history collections made by the Tradescants, and miscellaneous objects of antiquarian interest, which in the course of time swamped the natural history. Now, under the care of Mr. Arthur Evans, reorganized and rearranged, it is taking its place among the educational institutions of the University. It was not until 82 years after the foundation of the Ashmolean that museums were recognized by the Government of this country in the establishment of the British Museum in 1749 by Act of Parliament.

The modern museum is the outcome of the Renascence, and must keep pace with those great accessions to our knowledge of the history of Nature and of Man which distinguish the new from the old learning of to-day. If it cease to grow it is dead, and should be removed. There is no finality in museum work any more than there is finality in the acquisition of knowledge.

The Muses should not be forgotten in museum arrangements, and form, beauty, and symmetry should be studied as well as the outlines of a rigid classification. As an illustration of this I would refer to the groups of birds in the Natural History Museum at South Kensington, or to some of those in the museum at Newcastle. "A thing of beauty is a joy for ever." There is no reason why things beautiful in themselves should be treated so as to repel rather than attract. The element of fit association, too, is one of the important principles. In the case of the temporary exhibition of pictures in the Academy, the fit association of subjects cannot be studied, but there is no reason why in an art gallery the Muses should be scared by a Venus being placed close to local worthies, or a Madonna close to a party of Bacchanals. In museums as in armies the results are largely dependent on the leaders, who leave the impress of their personal character on their commands. The impulse to the new learning given by Ashmole, Hunter, Flower, and by Franks and Newton in this country, by Leidy, Dana, Marsh, and Agassiz in the United States, will last as long as the museums which they founded and organized. In Paris the name of Cuvier is inseparably bound up with the Museum of Natural History in the Jardin des Plantes. In Berlin the Ethnological Museum, and the anatomical collection at the Charité, will keep fresh the memory of Bastian and Virchow in a far distant future when the names of the great political leaders of these times are fading away. It is, therefore, of primary importance to choose good leaders for museum work, and to offer those inducements which will command the services of the best men.

The Old Local Museums in Britain.

When I first began to study the question, some thirty years ago, most of the local collections in this country were in a deplorable state. They consisted largely of miscellaneous objects huddled together with more or less care, and more or less—generally less—named. In one you saw a large plaster cast of a heathen divinity, surrounded by stuffed crocodiles, fossils, and models of Chinese junks, which looked like the offerings of devout worshippers. In another I remember a small glass case containing a fragment of human skull, labelled "human skull," and a piece of oatcake, labelled "oatcake," while underneath was a general label with the inscription, "A piece of human skull very much like a piece of oatcake." In a third wax models were exhibited of a pound weight of veal, pork, and mutton chops, codfish, turnips, parsnips, carrots, and potatoes, which must have cost the values of their originals fifty times over. They had labels explaining how much flesh and fat they would make—theoretically—for we who are either lean or fat know that the personal equation has to do with the actual results. They were as carefully modelled as the most delicate preparations of human anatomy. I quote them merely as illustrations of the misapplication of time, money, and museum space.

In many collections art was not separated from natural history, nor from ethnology, and the eye took in at a glance the picture of a local worthy, a big fossil, a few cups and saucers, a piece of cloth from the South Seas, a model of a machine, and probably also a mummy. These objects would be all very well in their places, but being matter in the wrong place, they were covered by the Palmerstonian definition of rubbish. Such collections as these neither please nor instruct. They have no more right to the name of a museum than a mob has to be called an army. Most of us, I think, are acquainted with this type of collection, which is rapidly becoming extinct with the spread of knowledge. I merely quote them as examples of a state of things from which we have fortunately escaped.

The Place of Museums in the New Learning.

The rapid increase of knowledge makes it more and more necessary for museums to be organized, so as to be in harmony with the swiftly changing conditions. The study of things as well as books is daily growing in importance. The historian, for example, formerly content with written records, now counts the results of archæological discovery among the most valuable and trustworthy of his materials in dealing with the history of the past. The story of Ancient Greece is incomplete if the explorations at Mykenæ and Ilios, in Athens, in the Greek islands, and in the Egyptian cities and tombs be left out of account. To the historian the collections of Schliemann, Flinders Petrie, and others are most precious. Nor are they less precious to him who studies art, or to the ethnologist who studies civilization, or to the naturalist who is interested in the distribution of the various types of mankind, or to the technologist who looks to the evolution of handicrafts. The public mind is beginning to realize the value of well-organized museums for purposes of special research as well as of general culture, and thus they appeal to the interest of the many, while books and a taste for books interest a narrower circle. To contemplate in the British Museum the frieze of the Pantheon is of itself an education in Greek art and in Greek ideas of beauty, and the most unlettered visitor to the Natural History Galleries cannot fail to carry away new ideas about the realm of nature. It is obvious, therefore, that in museums we have an instrument of great educational value, if they be organized to meet the increasing demands of modern investigation.

The Classification of the Museums of To-day.

The museums of to-day fall naturally into four groups. (1) The Art Museum, which includes also antiquities arranged from the art point of view. (2) The Natural History, which illustrates the history of nature in its widest sense, and of man in his physical aspects. (3) The Archæological and Ethnological, which deals with the works of man and his progress in civilization. (4) The Technical, in which objects are arranged in relation to industry. The leading idea of the first is art, of the second nature, of the third civilization, and of the last the conquest of mind over matter.

The Principles of Museum Organization.

These four groups are sharply defined from each other. In practice however it is often necessary to use for the illustration of one what, strictly speaking, belongs to the others. In all such cases, however, the reason of the presence of the alien object must be made obvious, if the general effect of the arrangement is to be preserved. For example, in the Manchester Museum, I found it necessary to complete the history of the Tertiary Period to illustrate the first appearance of man, and to carry on the narrative through the prehistoric and historic divisions down to modern times by a small selected series of specimens, showing the progress of mankind. Were it not for this they would be wholly out of place in a collection of natural history. In like manner our Egyptian mummy has its due place in the National Gallery in Trafalgar Square, its *locus standi* consisting in the fact that it illustrates the art of portrait painting among the Alexandrine Greeks of the first century after Christ.

Next in the point of importance to the leading ideas in museum work comes the question of labelling and illustration. The labels should be clear and distinct, and if possible in English as well as in Latin. The specimens should illustrate the labels quite as much as the labels the specimens. All possible means of illustration should be employed, maps, diagrams, restorations, and the like, so that the main points and relations are clearly brought home to the visitor. In addition to the systematic catalogue of each specimen there should also be a popular guide similar to those of the British Museum. It goes without saying that a collection of books is also necessary.

The kind of museum most desirable in any place depends entirely on the local conditions, and there is no hard and fast scheme applicable to all cases. Nor is the question of great or small to be looked at otherwise than as one of detail. A small well-arranged collection in a school or in a village will do the work which it is intended to do as well as large museums in the metropolis, or in a university, or in a centre of commerce. The principles of success are the same in all : they must be orderly, they must be intelligible, they must as far as possible appeal to the sense of beauty. Under no circumstances must unnamed and unknown specimens be allowed to appear. A ragged recruit may be drilled into a good soldier, but he spoils the parade if he appears out of uniform in the ranks. Nearly all of us who have had to do with museums have sinned in this matter, and it is not for me to cast a stone at my fellow sinners.

The work, however, is only partially done when a museum is properly arranged, labelled, and catalogued on the above lines. To make it intelligible in the best possible way, it is necessary that there should be lectures and demonstrations given in the museum itself, in which some special points should be taken up which interest either the general public or the special worker. In my experience oral instruction with the things before the eyes in the museum, and not away from it in the lecture-room, is the best manner of doing this. As an example of this, I would refer to the demonstrations organized in the British Museum by Prof. Stewart Poole, in which ancient art and civilization were dealt with, and to those which have from time to time been given in the national collection of natural history, under the auspices of Dr. Flower. In this relation the British Museum will be found to be one of the most valuable instruments for spreading knowledge in the University which London will have in the future. In this relation, too, the Geological Museum in Jermyn Street, around which are centred some of the ablest men of the time — De-la-Beche, Murchison, Ramsey, Edward Forbes, Tyndal, Huxley, and many others—has done most valuable service. It is in this direction that museums will influence the general education in this country, and take their natural place in the new learning.

Application of these Principles to the Manchester Museum.

I pass now to the application of the above principles to the Manchester Museum, Owens College. Our experience gained in bringing the old collection into harmony with modern requirements cannot fail to interest those who are now engaged in like work, because it may show not only what is to be copied, but what is to be avoided.

When the task of organization was entrusted to me in 1869, there was a large general collection of natural history, and a large geological collection. The former had been a first-class collection in the second quarter of this century, but had ceased to grow, and therefore had become dead. The second was in good order, and, under the care of its founders, Binny, Ormerod, and others, was properly named. Both, however, were in a most deplorable state so far as relates to fittings, and were simply ignored by the general public, and scarcely used by students. The first step was to sweep out of the way the miscellaneous objects which had no place in a Natural History Museum. The next was to organise what remained into a systematic collection in rooms and cases which were unfit for the purpose. Then followed evening lectures and demonstrations in the old Museum building in Peter Street. Later the teaching collections in Owens College were added, and the Museum began to revive and grow, slowly but steadily, as the connection with the College grew closer, till, in 1874, it was transferred to temporary quarters in the attics and basement of the Owens College. It continued to grow in spite of the removal and of the inadequate cases, and the interest of the public was maintained very largely by the system of Saturday afternoon demonstrations in the only part open to the public—the Geological Museum.

The systematic rearrangement in view of the new buildings was taken in hand. The minerals were arranged, labelled, and catalogued, Dana's "Hand-book of Mineralogy" offering a ready-made catalogue. To meet the mining interests of Manchester special groups of the minerals found in association were organized to illustrate the minerals of Derbyshire, the Lake District, Cheshire, the diamond mines, the apatite mines, and the like.

For the special ends of the geological teaching, the rock specimens were also arranged, and special groups were formed to illustrate their association—such as the products of Vesuvius, and of the volcanoes of Auvergne—and to illustrate the destruction of rocks by natural causes. Then naturally followed the classification of the fossils to show the sequence of events in the geological record. In this the Carboniferous flora and fauna naturally took a prominent place, because of the vast importance of the coal-fields to this district. The arrival, too, of the existing higher Mammalia, including man, on the earth, took a prominent place in the Tertiary collections, and formed the leading idea in the Tertiary chapter of a history of the earth, while the story of the earth was fitly closed by a series of groups illustrating the evolution of human culture and the prehistoric and historic periods. The general principle of classification throughout the whole geological series, or, in other words, the historical method, was that of *time*. Next the zoological collections were arranged, as far as the changing classification would allow, zoologically, with a special group for the zoology of Great Britain. The botanical collections, which offered exceptional difficulty, are now in hand. In this manner the whole of the collections were arranged for the time when they should find their place in the new buildings, and pass under the care of the professor in each department. A scheme of uniformity was carried out with regard to fittings and mounts also ; a definite unit of size, 4″ × 1½″, was decided upon, and all tablets and glass boxes were made either on that or on multiples of that. This unit also ruled the size both of the drawers and of the cases in the new fittings. The system of printed labels in which black ink represents the specific name and the red the name of the group was also devised. In the plans of the new Museum the maximum amount of light, consistent with stability and architectural beauty, was the leading idea, while the laboratories and lecture-room of the whole of the Natural History Department of the College were brought as close as they could be to the Museum. The building itself was designed to suit the organization of the collections. Thus step by step the present Museum was gradually built up, and when the buildings were completed in 1884 the collections were transferred to the quarters which they now occupy, and where they form a centre towards which other collections gravitate.

While the museum has been rapidly growing during the last eight years, the system of museum lectures and addresses to various organizations, mechanics' institutes, schools, and the like has been largely developed. In its present state it is used largely by students of Owens College, and is growing in favour with the general public. In other words it is taking the place it ought to have in the education of this densely populated district. These results, it must be observed, have only been possible through the liberality with which the Museum has been treated both by the public and by Owens College. I look forward with confidence to the time when both will be amply repaid by the impulse it is giving, and will give, to the new learning.

I do not for one moment suppose that a natural history museum of this kind is suitable for all places. The *genius loci* must be, in all places, the genius of the museum. The principles however of success are the same in all, and success can only be achieved in a limited degree if there be no signs of the worship of some of the Muses in the arrangements.

The Work of the Museums Association.

In ending this address, all too long, I fear, for my audience, all too short for my subject, I must add a few words as to our work as a Museum Association. It is twofold. First, we must arouse ourselves to the present situation and note the directions which the intellectual movement of the day is taking. Next, it is our duty to arouse the public to the importance of museum development, and to take care that the claims of museums as instruments of education shall not be ignored in the grants made by public bodies for the good of the commonweal.

ON THE CARBURIZATION OF IRON.

I.

THE conditions under which carbon combines with iron have been closely studied, and the observed phenomena fully discussed. Even now, however, it is doubtful whether true chemical combinations of carbon and iron are formed. It has been alternatively assumed that carbon is with difficulty soluble in iron, and that at low temperatures solution may proceed very slowly. In other words, carbon is not easily dissolved except at high temperatures ; and it follows that if highly heated iron fully charged with carbon be cooled, a portion of the carbon must be precipitated in this state, existing simply as foreign matter in the metal, but that, on reheating, it may again enter into solution. Low carbon steels may be regarded as dilute solutions of carbon in iron ; pig or cast iron as saturated ; and intermediate grades may be termed moderately concentrated solutions.

Against this, however, there is a mass of evidence which deserves attention and cannot be ignored. Percy states that for the full carburization of iron a high temperature is necessary, and further, considering the absolute infusibility of carbon, it seems reasonable to assume that these elements must enter into chemical combination. It is, however, admitted that this compound may have the power of dissolving additional carbon ; this explains the copious deposition of carbon in the graphitic form when iron is cooled. Dr. Percy finally concludes that there must be at least one definite compound of carbon and iron, but adds that there seems to be no reason why solution should not occur, as in the case of mercury, which liquefies gold, silver, or copper.

Prof. Roberts Austen also ("On Certain Properties common to Fluids and Metals," Royal Institution, March 26, 1886) speaks of the power which certain solid metals have of even rapidly taking up fluids—clearly cases of solution. Abel claims to have proved the existence of a definite compound of carbon and iron. Prof. Roberts Austen also finds that heated iron combines with pure carbon in the form of diamond dust. The author also has succeeded in directly combining iron fused *in vacuo* with pure sugar charcoal presumably freed from gases by repeated heatings *in vacuo*. Yet it is obvious these instances may all be explained on the theory of solution at elevated temperatures, with the exception of Prof. Abel's, who claims to have isolated a definite carbide of iron from the metal.

Matthieson, as the result of an elaborate research, states that "with few exceptions" most of the known two-metal alloys are solidified solutions of one metal in another. Carbon-iron alloys may be looked upon as solidified solutions of carbon in iron, and the analogy of cast iron with other alloys indicates the non-existence of chemical combination between carbon and iron.

Again, viewing alloys as definite chemical combinations, the facility with which heated iron absorbs certain gases does not admit of easy explanation.

Deville, however, imagines a kind of porosity in the metals, terming it an intermolecular porosity, sufficient to admit of the passage of gas at a low temperature ; and supposes it developed by the expansive agency of heat. Graham assumes that the affinity of the gases for iron and platinum is as the attraction admitted to exist between a soluble body and its solvent.

Other metallurgists are of opinion that carbon does not directly combine with iron, attributing their union to the direct action of carbon monoxide gas always present in iron ; by the agency of this gas carbon is indirectly transferred to iron ; but it would appear that this cannot be maintained, for it has been proved that carbon combines directly with iron one way or the other, *i.e.* by solution or chemical combination.

Whatever may be said of irons containing an excess of carbon, *i.e.* cast iron and very hard steel—which, if one grants that carbon is not very soluble in iron at a low temperature may be termed supersaturated solutions—in the case of low carbon steels there seems some ground for assuming that carbon is merely dissolved in the metal.

Sir L. Bell tells us that, on heating thin sheets of carburized metal or steel piled closely together, the excess of carbon contained in one or more of the sheets is transferred to the others. Wrought iron is carburized in much the same manner by the cementation process, and it is equally possible that heterogeneous iron, *i.e.* iron containing intermixed carbon or graphite, and as a rule not equally diffused, may by continued sufficient heating become practically homogeneous.

It is a well-known fact that the carbon in low carbon steel —for instance, Bessemer steel—exists in at least two different forms ; Prof. Ledebur says four. Akerman (Iron and Steel Institute) classifies these as (1) hardening carbon, or the carbon which determines the quality of steel, (2) cement carbon, and also graphite may be present.

The united researches of many workers in this field of research indicate generally that a portion of the total carbon is in intimate union with the metal, and that the more intimately combined or hardening carbon determines the quality of the steel. The carbon incompletely combined (or intermixed carbon) is termed cement carbon, because it occurs in the largest proportion in blister or cement steel.

Does not the above point to a case of solution of carbon, in which the quantity in solution is determined by temperature, just as with other solutions ?

Metallurgists, however, can hardly accept the theory of solution without qualification.

Mr. Spencer states that "unhardened steel containing 1·18 per cent. total carbon—of which the colour test indicated ·89 per cent. as combined carbon, and residual carbon or graphite ·29 per cent.—after being hardened, gave only ·58 by colour test, and only traces of graphitic carbon, showing a loss of ·51 per cent. of carbon. A softer steel, containing ·50 total carbon—equalling ·45 per cent. by colour test, ·04 per cent. graphitic carbon—after hardening, only ·21 colour test carbon ; graphitic carbon ·00, showing a loss of ·29 per cent. Other analyses were made confirming the above, and establishing the fact that after hardening there is always a proportion of carbon which can neither be determined as graphite or by the colour test, and this proportion is found to increase according to the larger amount of carbon in the metal, and the rapidity with which it was cooled" (Mr. Spencer, Iron and Steel Institute).

The facts above quoted are not apparently in accord with the theory of solution ; but there are undoubted allotropic modifications of carbon, and this peculiar form may be one of these, "uncombined," and may be classified with the graphite, or really as merely intermixed foreign matter.

There is the alternative assumption that the missing carbon may exist in some form or combination with the iron, possibly not capable of being registered by the colour test ; but as the steel is treated with dilute nitric acid, in which it is completely soluble, with the exception of the graphite, this assumption can hardly be maintained.

Referring to Akerman's assertion that only combined "hardening" carbon determines the physical properties of steel—an assertion with which Mr. Spencer agrees—"The apparent loss of carbon shown by the latter, and which we have determined as intermixed carbon or a form of graphite"—it may well be that the missing carbon is so intimately mixed as to be in a state closely bordering on solution, for it is well known that it is difficult to draw the line between absolute solution and matter finely suspended in a liquid. The latter practically often presents the appearance of a solution scarcely to be distinguished from it. Messrs. Harold Picton and L. E. Linder (Chem. Soc., January 1891) are of opinion that there is a continuous series of grades of solution passing without break from suspension to a crystallizable solution. This seems very probable, and in accordance with our chemical experience.

Graphite, if the author has adequately grasped Prof. Akerman's views, has little or nothing to do with the quality of